AIR QUALITY MONITORING IN AN URBAN AGGLOMERATION*

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The paper describes the experience and results from one year of air quality monitoring campaigns in the Romanian city of Timisoara. Air quality measuring is still less experienced in Eastern European countries. The University “Politehnica” from Timisoara undertook on line experiments in urban areas, using measuring methods in accordance to the national and European legislation but also remote controlled open path techniques. Air quality measurement of NOx, SO2, CO, O3 and VOCs concentrations has been done in several locations in Timisoara.

Key words: air pollution, air quality monitoring, AQM, point measurements.

1. INTRODUCTION

The paper is an attempt to describe complex problems concerning air quality in the Romanian city of Timisoara, in a European perspective. The town is one of the most developed ones in Romania, famous for its history and rapid progress into a modern but traditional location of human development [1]. Air pollution in a modern city has became a serious environmental problem, because of the combined effects of various pollutants upon the physical and mental health of citizens and the quality of urban life in general [2], [3], [4]. Urban air pollutants arise from a wide variety of sources although they are mainly a result of combustion processes. Today, the largest source of pollution in urban areas is the fleet of transportation (motor vehicles), and to a lesser extent industry and household. Traffic-generated pollutants include nitrogen oxides, carbon monoxide, volatile organic compounds and particulates. On warm summer days the strong sunlight leads to a buildup of ozone through the oxidation of volatile organic compounds (VOCs) such as benzene, in the presence of nitrogen oxides. However, due to the special atmospheric chemistry of ground level ozone, the active altitude, where the reactions are occurring, is often lower in urban areas than in the countryside.


Health impacts of vehicular exhaust pollutants are well documented. Irrespirable suspended particulate (RSP), or PM10, and gaseous pollutants such as nitrogen oxides are known to have detrimental effects on human health and the relationship between air pollutants and health has been widely studied - an increase in yearly average PM10 concentration increases the number of respiratory hospital admissions and the mortality rate [5]. There is also an association between concentration of nitrogen dioxide (NO₂) and hospital admissions associated with cardiovascular diseases. Nevertheless many authors achieved research in the domain, for the Balkan region especially [6], [7], [8]. Many cities set up fixed air quality monitoring stations to monitor the air quality on a continuing basis and to measure concentrations of major pollutants at roadside and urban background locations. Many cities and countries have also set short- and long-term air quality objectives for acceptable, alert and limit concentration levels of pollutants. Based on observations made at monitoring stations, advisories and warnings are issued when concentration of one or more pollutants exceeds the values. The planning authorities may also use measurements at background monitoring stations to formulate pollution abatement measures and to examine the effectiveness of these measures. Long-term measurements at monitoring stations may be used to investigate the relationship between the population exposure to air pollutants and the incidence rate of diseases [9], [10].

There are many ways to measure air pollution, with both simple chemical and physical methods and with more sophisticated electronic techniques, in addition to modeling possibilities, according special tailored programs, according emission factors and pollutant inventory, for real or probable meteorological conditions [9], [10], [11]. Passive sampling methods provide reliable, cost-effective air quality analysis, which gives a good indication of average pollution concentrations over a period of weeks or months. Passive samplers are so-called because the device does not involve any pumping. Instead the flow of air is controlled by a physical process, such as diffusion. Active sampling methods use physical or chemical methods to collect polluted air, and analysis is carried out later in the laboratory. Typically, a known volume of air is pumped through a collector (such as a filter, or a chemical solution) for a known period of time. The collector is later removed for analysis. Automatic methods produce high-resolution measurements of hourly pollutant concentrations or better, at a single point. Pollutants analyzed include ozone, nitrogen oxides, sulfur dioxide, carbon monoxide and particulates. The samples are analyzed using a variety of methods including spectroscopy. The sample, once analyzed is downloaded in real-time, providing very accurate information. Remote optical, long path analyzers use spectroscopic techniques, make real-time measurements of the concentrations of a range of pollutants.

The paper relates to the experience and results from a range of over 50 days of air quality monitoring campaigns in the Romanian city of Timisoara, achieved in special selected sites, for which local concern and complain raised: cross roads,
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industrial areas, and in parks. Research has been carried out in order to detect the effects of the principal polluting sources of the city, and to measure their contribution to the general situation of the air quality. The semi-mobile monitoring station was in operation for a period of 3 years, beginning in 2006 and ending in 2008, in episodes of 7–10 days. Air quality measuring is still less experienced in Eastern European countries. The authors undertook online experiments in urban areas, using measuring methods, in accordance to the national and European legislation (point source measurement), but also remote controlled open path techniques. The values measured may be analyzed as scientific values for the monitoring periods, on the specific locations, and may be used scientifically to raise alert and interest of the local community and inform the population. The national AQM monitoring network for Timisoara is responsible for the general monitoring and, presently it consists of several stationary working stations for the entire city. The disadvantage of being fixed determines that they measure only in the local area, and only if all are functional in the entire city, might determine an average attested value. If a particular episode or a special site is of concern, only a mobile laboratory, specialized and attested, might perform such relevant data measuring, online. Air pollutants and meteorological parameters were measured continuously over the episodes and stored as \( \frac{1}{2} \) h and 24 h mean values. The \( \frac{1}{2} \)h mean value was preferred over the regulated 1h mean value in order to capture high peaks of pollution, for better identification of pollution sources and influences. The comparison between measured values and regulated admissible limit values was not a major purpose of this study.

In Romania flue gas control and air quality analysis have not a traditional approach and presently efforts are notable, direct from the ministry and authorities of resort, agencies, but also independent laboratories, institutes and industrial units. The flue gas monitoring equipment at sources is expensive and available only in some major power stations or main polluters, the control of the pollutant emissions at the source is presently achieved, on a regular program, approved individually by the environmental agencies, through direct measurements once per year or in best cases quarterly or monthly. The traffic fleet consists of modern but also poorly equipped automobiles and other vehicles, theoretically fitting the EURO II up to IV norms, but practically far from these. In the 2008 yearly report of the National Romanian Automobile Registry (RAR) it is shown that the Romanian automotive fleet consists in 54 % non-euro vehicles, 11 % are Euro II compliant and only 35 % of total Romanian registered road vehicles respect Euro III and IV regulations, thus aspects regarding the direct traffic pollution, also with other pollutants, in addition to the classic ones [12], [13], [14]. Emission and air quality standards are according to the EU norms filling these limits, and in many cases in discordance to the financial available possibilities in the country.
2. EXPERIMENTAL

The presented air quality monitoring campaign has been done in 2008 in several locations in Timisoara, each campaign for about 7 days. Timisoara is the second biggest city in Romania, with over 350,000 inhabitants and with 167,000 registered automobiles, a ration of 0.46 cars/inhabitant and the biggest ration for Romania. Figure 1 represents the locations of monitoring station (points) in all points over city of Timisoara, where measurements have been achieved in 2008.

![Fig. 1 – Location of the air quality monitoring campaigns in Timisoara, 2008. 1 – Village Museum, 2 – Divizia 9 Cavalerie, 3 – Mall parking, 4 – Botanic Park, 5 – Electromotor, 6 – Kuntz, 7 – Cet Sud.](image)

During the campaign sulfur dioxide SO₂ (with Horiba APSA370 apparatus–fluorescence principle), nitrogen oxides NOₓ (with Horiba APNA370 apparatus–chemiluminescence’s principle), carbon monoxide CO (with Horriba APMA370 cross-flow modulated NDIR apparatus), methane, non-methane hydrocarbon and total hydrocarbon (with Horiba APHA370 apparatus – Flame ionization principle), ozone O₃ (with Horiba APOA350) and PM10 (LSV3 gravimetric apparatus) have been measured. At the same time the traffic structure has been establish and meteorological parameters recorded (wind speed and direction, air temperature and humidity). All equipments are calibrated at the start of the campaigns with traceable to NIST provided special calibration gases and under strict EN ISO/CEN 17025:2005 quality control specifications. An exception was the APOA350 ozone that was not calibrated due to a malfunction in the O₃ calibration generator, attested during the monitoring campaign.
In figure 2 the conceptual scheme of the air quality monitoring station is presented. All instruments are programmed to measure the pollutants concentration in air continuously, and the output signal is collected and recorded by a data acquisition PC board. All instruments are calibrated with etalon gases, traceable to the station. The monitoring station is equipped with a metrological verified station and the values for wind speed and direction, air temperature, pressure and humidity are continuously measured and recorded.

The concentration in air of significant air pollutants is regulated by European directives, directives implemented in Romanian legislation. The limit values (in reference to normal pressure and 20 °C) for concentration of the pollutants measured are:

- for SO₂ the limit is 350 µg/m³ (one hour mean value) and is regulated by 1999/30/CE Directive;
- for NOₓ the limit is 200 µg/m³ (one hour mean value) and is regulated by 1999/30/CE Directive;
- for CO the limit is 10 mg/m³ (8 hours mean value) and is regulated by 2000/69/CE Directive;
- for O₃ the limit is 120 µg/m³ (8 hours mean value) and is regulated by 2002/3/CE Directive;
- The EU Directive that will regulate the CH₄, VOC (NMHC) and THC is under development, only benzene concentrations in air are limited in 2000/69/CE Directive, and the annual limit value is 5 µg/m³.
In figures 3 and 4 the hourly mean values recorded for Village Museum location are presented. The Village Museum is located in the North-Eastern part of Timisoara surrounded in the Eastern part by a large forest and in Western part by the biggest industrial area of the city. It is away from major city roads. The recorded values for NO$_x$, O$_3$, SO$_2$ and CO are under the limit value regulated by European legislation. The values for VOC (figure 4) present high peaks even during the night so one may conclude that the source of VOCs is the nearby industry, where activity is continuous, as the traffic is reduced during night, in comparison to the day.

Fig. 3 – Measured values in Village Museum, Timisoara 2008.

Fig. 4 – Measured values in Village Museum, Timisoara 2008.
In figure 5 and 6 mean values (hourly) recorded for the Botanic Park location are presented. The Botanic Park is situated in the center of the city and is surrounded by major city roads. There is no industry in the vicinity. The recorded values for all air pollutants measured are below the admissible limit. The VOCs are close to zero, being generated only by automobile exhaust gases or local individual house heating systems, and the CH₄ values are considered around global background.

Fig. 5 – Measured values in Botanic Park, Timisoara 2008.

Fig. 6 – Measured values in Botanic Park, Timisoara 2008.
The Divizia 9 Cavalerie Street is located in the Northern area of the city, and is a major street with national relevance, practically all the road traffic (including heavy trucks) from South-Eastern Romanian areas to the Western Europe is going thru this street. All the recorded values are high but only NO₂ concentrations are over the permitted limit. VOCs concentrations are also high and not variable thru time so that the North-East Industrial area is the source for the VOC pollution.

Fig. 7 – Measured values at Str. Divizia 9 Cavalerie, Timisoara 2008.

Fig. 8 – Measured values at Str. Divizia 9 Cavalerie, Timisoara 2008.
The Mall parking is a central location, with lots of pedestrians traversing it. All recorded values are under the regulated limits, for all pollutants. Despite the different values, the tendency of evolution is comparable for all species, thus attesting that the answering and recording periods for the campaigns were correct selected.

Fig. 9 – Measured values in Mall parking lot, Timisoara 2008.

Fig. 10 – Measured values in Mall parking lot, Timisoara 2008.
The recorded mean values for all pollutants are presented in figures 11 and 12, for CET SUD location. CET SUD is a coal combustion power plant; during the monitored period was stopped for technical revisions, thus one can explain the reduced SO₂ values. Even so, the recorded values for NOₓ are over the limit with several peaks, caused probably by heavy industrial machines, gasoline powered.
3. CONCLUSIONS

Following main conclusions are driven:

- For all episodes the recorded values for ozone $O_3$ should be interpreted with precaution, or ignored, due to a malfunction in the $O_3$ gas calibration generator. The ozone analyzer was not properly calibrated.
- In the location Village Museum (close to a industrial area) the recorded values for NMHC (VOC) are very high, around $2 – 3 \, \text{[mg/m}^3\text{]}$ and the highest recorded values are mostly occurring during the night. This observation is valid for all North-East locations that are surrounding the Industrial park, one of the major from Timisoara that comprises major petrochemical industry.
- In the Botanic Park (center area) one can easily observe the influence of the road urban traffic from the area but the recorded values are not over the regulated limit values. Similar conclusion might be driven for Divizia 9 Cavalerie Street, where road traffic is also the dominant cause for the air pollution.
- For the Electromotor (industrial area in the city) campaign all the recorded values are exceeding the regulated values, especially for NO$_x$ and CO. The cause for this is also the road traffic, as the location is close to a very important city entrance, with long stops at the traffic lights, and often occurring jams.
- For the Cet Sud (power plant) location the values are low (except for NO$_x$) mainly because the power plant was not started.

In general, for the city of Timisoara one can conclude that the air quality regulations are accomplished, with some exceptions for NO$_x$ concentrations near the city roads. A cause for this situation is considered the fact that Timisoara is crossed by two major European roads, E70 and E671 and it had, by the time of investigation, no city road rings. Higher values for VOC (NMHC) have been recorder only in locations around the Nord-East Industrial area of Timisoara. A strict control of the state authorities must impose the control of the VOC emissions at the sources, in the area, directly at the emitting sources.

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